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(54) IMPROVEMENTS IN SIGNAL DISPLAY MEANS

(71) We, CARL-ZEISS-STIFTUNG, a Foundation established under the laws of Germany, trading as JENAER GLASWERK SCHOTT & GEN., of 10 Hattenbergstrasse, 65 Mainz, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to signal display means and is particularly concerned with a device whereby letters, numerals or other signals can be displayed.

Conventional signal display devices usually consist of a plurality of lamps arranged to form a pattern with an optical system in series with the lamps to produce the required illumination characteristics. The lamps are normally so connected that different signals are displayed by different combinations of the lamps.

Disadvantages of such display devices are that they have a low light output, that a considerable number of lamps are required and that there are many times when the devices are not functioning properly because of lamp failure. Complicated wiring patterns are required and there is also the possibility that, when lamp failures occur, the indicated signal will be misinterpreted. Each lamp provides a dot of light in the display of the various signals so that it is only practical to provide monochromatic symbols or displays. In mist or fog, problems are encountered as a result of the poor resolution of the signal. Furthermore, limitations are imposed on the size of the display device by the dimensions of the lamps.

Light-transmitting fibres have been used for the display symbols on indicator surfaces and are illustrated in German Patent Specifications Nos. 2,126,672 and 2,245,460. However, with these arrangements, the intensity of the light issuing from the ends of the light-transmitting fibres has been insufficient both as regards the total light intensity and also with regard to the intensity of the light within a selected angle of emission.

It is an object of the invention to provide improved signal display means.

According to the invention, we provide signal display means including a multi-strand light guide comprising a plurality of light-transmitting fibres each having a first end and a second end, the first ends of the fibres being bundled together to provide a common inlet end of the light guide and the second ends of the fibres being separated from one another to provide a display matrix, characterised in that either a light-conducting cone is coupled optically to said common inlet end of the light guide or a light-conducting cone is coupled optically to the second end of each of said fibres.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 illustrates schematically the passage of light rays through a light-conducting cone, and

Figure 2 is a schematic perspective view of a display device which includes a plurality of such cones.

The light-conducting cone 1, shown in Figure 1, includes a cone 2 formed of a transparent material having a refractive index n_K, the cone 2 being surrounded by a sleeve 3 formed of a material having a refractive index n_M which is less than n_K. Substantially total reflection of the light rays within the cone 1 is obtained at the interface 4 between the cone 2 and the sleeve 3.

Figure 1 shows two light rays 5 and 5′ passing through a medium having a refractive index n_1 and impinging on the end surface 6 of the cone at an angle α_1. This end surface 6 has a diameter d_1 and the light rays pass through the cone 1 and issue from the opposite end surface 7 thereof at an angle α_2 to the end surface 7 which has a diameter d_2. The medium into which the light rays are emitted has a refractive index n_2.

The inlet aperture A of the cone$=n_1 . \sin \alpha_1$, the exit aperture E of the cone$=n_2 . \sin \alpha_2$ and there is the following relationship between the two apertures

$$A = \frac{d_2}{d_1} . E$$

i.e.

$$n_1 . \sin \alpha_1 = \frac{d_2}{d_1} . n_2 . \sin \alpha_2$$

In addition, the maximum value of the inlet aperture Amax is defined by the relationship

$$Amax = \frac{d_2}{d_1} . \sqrt{n_K^2 - n_M^2}.$$

The exit angle α_2 of the rays 5, 5′ issuing from the light-conducting cone can be selected by appropriate selection of the ratio $d_2 : d_1$, i.e. the exit angle α_2 is dependent on the geometry of the cone. However, the spacing between the end surfaces 6 and 7 of the cone 1 is immaterial and it is only the diameters d_1 and d_2 of the end surfaces of the cone that are important.

As can be seen quite clearly from Figure 1, the light rays 5, 5′ at the exit side of the cone 1 are inclined at an angle α_2 to the axis of the cone which is substantially less than the angle α_1 at the inlet side of the cone 1. Because of this reduction in the angle (α_2) which the light rays make to the axis of the cone at the exit side thereof as compared with the angle (α_2) at the inlet side of the cone, the beam of light issuing from the exit surface 7 has a smaller cross-sectional area (at a distance from the cone 1) than the beam of light impinging on the entry surface 6, i.e. the cone 1 serves to effect an increase in the intensity of the light beam.

One of the characteristics of a light-transmitting fibre is that a light ray which enters one end of the fibre at a given angle to the longitudinal axis of the fibre will, after a series of reflections along the length of the fibre, issue from the other end of the fibre at the same angle to the axis. It does not matter whether the light-conducting cone 1 is placed at the common inlet end of a bundle of fibres or whether individual cones are placed at the exit ends of the separate fibres. Of course, if the latter course is adopted, there is a change in the profile of the beam dependent on the difference in the diameters at the two ends of the cone. It is thus possible to obtain an increase in the cross-sectional area of a light beam whilst at the same time reducing the degree of scatter of the beam.

If the light-conducting cone is, on the other hand, disposed at the common inlet end of a bundle of photoconductive fibres, the larger diameter surface 7 of the cone 1 will be connected to the fibres and the light from the source will be emitted on to the smaller diameter surface 6. Known forms of optical devices may be employed for concentrating the light beam on to said end surface 6.

Assuming that Figure 1 represents a longitudinal section of a circular cross-section photoconductive cone, the light rays 5, 5′ are radiated from the cone at an angle α_2 to the axis of the cone throughout the whole of the circular surface 7. However, if it is desired to obtain an emitted beam which is not symmetrical about the axis of the cone 1, it is possible to employ a cone having an end surface 7 of non-circular form. For example, it may be desired that the radiated beam should have a substantial horizontal spread but should be confined in the vertical direction to eye level. In such a case the exit surface 7 of the cone 1 would have a vertical dimension greater than the horizontal dimension thereof. It might even be desirable for the horizontal dimension of the exit surface 7 to be less than the diameter of the entry surface 6. In addition, means may be provided whereby the geometric shape of the exit surface 7 can be varied in dependence on the particular requirements prevailing at any selected time.

Figure 2 illustrates a signal display device the design of which is such that two signals of different colours can be displayed on the one indicator board. The device includes two multi-strand light guides 8, 8′ the individual free ends of the fibres of which terminate in openings 9, 9′ of a board 11. A circular light-conducting cone 1 is provided at the free end of each individual fibre 10, the cones 1 being set in said openings 9, 9′ with the exit surfaces 7 of the cones facing outwardly. A flat or convex panel 12 is fitted over the board 11 and serves to protect the end surfaces 7 of the cones 1. The panel 12 may be provided with an anti-reflective coating to counteract any phantom reflections which may occur. When we refer to phantom reflections we refer to external light (normally sunlight) reflected by the indicator device and thereby producing a luminous image without the light source of the device being switched on. Phantom reflections could arise from any of the reflecting surfaces within the device.

In order to reduce the production of phantom reflections and to increase the light output, the light-conducting cones 1 are coupled optically to the ends of the light-transmitting fibres, i.e. they are connected using an optical putty or jointing fluid having a refractive index identical to that of either the fibres 10 or the cones 1 so that the jointing medium does not cause refraction of the light beam passing therethrough.

The bundles of fibres 8, 8′ are illuminated at their common ends 13, 13′ by incandescent lamps 14, 14′. A colour filter 15 is disposed between the lamp 14 and the fibre bundle

end 13 so that, when the lamp 14 is switched on, a coloured signal is visible from the openings 9. In the example shown in Figure 2, there is no colour filter between the lamp 14′ and the fibre bundle end 13′ so that, when the lamp 14′ is switched on, an uncoloured signal is displayed.

Because of the relatively small dimensions of the cones at the ends of the optical fibres, the number of multi-strand conductors which are used can be increased considerably to permit the displaying of a variety of symbols on the one indicator board. In addition, several fibres, which are each obtained from different multi-strand conductors, can either be connected together to a shared cone or be disposed immediately adjacent one another in the display board with separate cones disposed in abutting relationship.

The light-conducting cones may be formed as optically insulated conical rods produced from an optically transparent material. It is important that the material forming the cones should have good light-transmitting characteristics and that substantially total reflection should take place at the interface 4 between the core 2 and the sleeve 3.

In a modified arrangement to that described above, the light-conducting cones are themselves each formed from a bundle of light-transmitting fibres, the bundle being disposed so as to form a cone. Since the change in the exit aperture in relation to the entry aperture of the cone depends solely on the ratio of the diameters of the end surfaces of the cone, it does not matter whether the cone is solid or formed from a plurality of fibres or whether the degree of taper thereof is constant throughout its length.

The light-conducting fibres may be so arranged that, although several lamps illuminate a signal, each individual lamp, when switched on, will cause illumination of that signal. This arrangement ensures increased operating safety in the event of failure of one or more of the lamps and facilitates controlled adjustment of the signal light intensity in dependence on the degree of illumination of the surroundings, i.e. in bright sunlight more lamps will be switched on than will be required on a dull day.

There is also the possibility that a single lamp can be arranged for alternative illumination of a plurality of different signals, selection of the signal required to be illuminated being effected either optically or mechanically. Colour filters can be used for the transmission either of multi-coloured signals or of signals of different colours by appropriate selection of the required filters. Coloration may be achieved either by the provision of additional elements for the signal display means or by appropriate pigmentation or other colour treatment of one of the optical components of the signal display means.

WHAT WE CLAIM IS:—

1. Signal display means including a multi-strand light guide comprising a plurality of light-transmitting fibres each having a first end and a second end, the first ends of the fibres being bundled together to provide a common inlet end of the light guide and the second ends of the fibres being separated from one another to provide a display matrix, characterised in that either a light-conducting cone is coupled optically to said common inlet end of the light guide or a light-conducting cone is coupled optically to the second end of each of said fibres.

2. Signal display means according to Claim 1, wherein a protective panel is fitted over the display matrix.

3. Signal display means according to Claim 2, wherein the protective panel is provided with an anti-reflective coating.

4. Signal display means according to Claim 1, wherein a plurality of multi-strand light guides are provided and separate light sources are arranged to illuminate the common inlet ends of said light guides.

5. Signal display means according to Claim 1, wherein a plurality of multi-strand light guides are provided and a single light source is arranged to illuminate the common inlet ends of said light guides.

6. Signal display means substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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1491142 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1

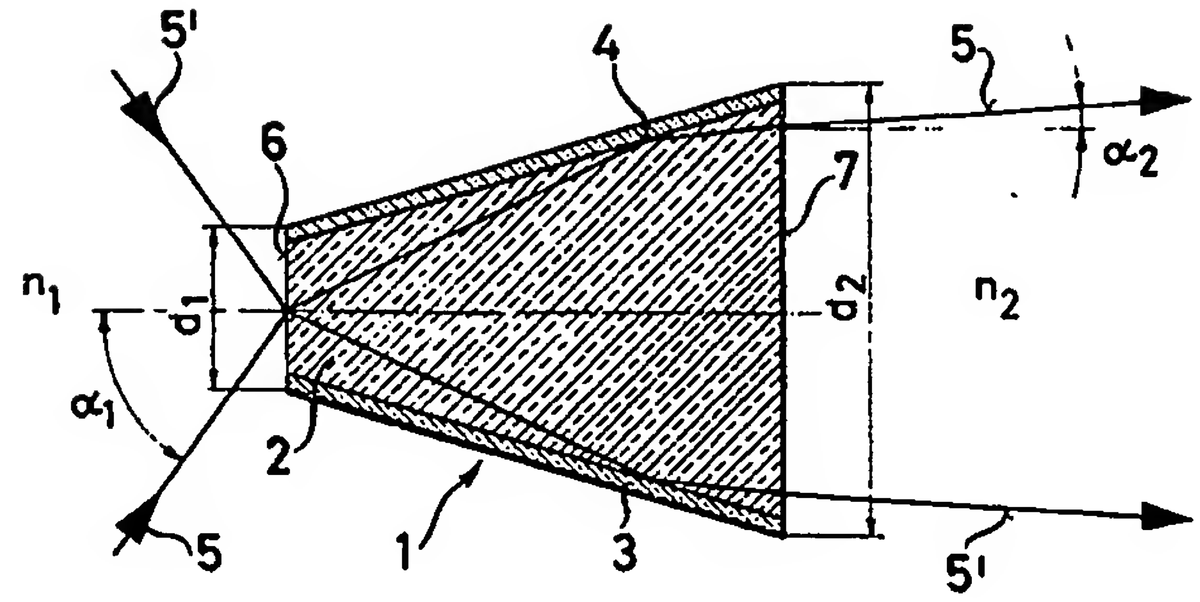

FIG. 2